

Perforating Gunshot Wounds of Abdomen

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THE operative mortality for perforating gunshot wounds of the abdomen remained above 50 per cent for many years. Not until 1943 when Hamilton and Duncan¹ reported their series was there a study of any considerable number in which the mortality was less than 50 per cent; in their study the mortality was 48.9 per cent. In recent years, there has been some tendency toward a lower mortality rate,² but as late as 1946, Wilkinson, Wright, and Hill³ reported a rate of 61.9 per cent in 115 cases.

This study is an analysis of fifty consecutive cases operated upon in Freedmen's Hospital in the seven and one-half years between July 1, 1941 and January 2, 1949. There were fourteen deaths in this series, a mortality rate of 28 per cent. Each case was a penetrating abdominal wound with perforation of at least one abdominal organ.

Before 1938 in our hospital, the mortality rate had been in the neighborhood of 67 per cent. In attempting to explain the better recent results, three factors appear to be of paramount importance: 1) the establishment of an adequate blood bank, 2) the availability in recent years of a series of sulfone drugs and the various antibiotics, and 3) the creation in our hospital of an approved residency program, which insures the presence of well trained young surgeons in the hospital at all times.

AGE AND SEX

In Table 1 the age distribution is given. The majority of patients were in the third decade, this group numbering 23 or 46 per cent. The youngest patient was two years of age and the oldest 52. The mortality tends to be greatest at the extremes of life.

TABLE 1—AGE INCIDENCE AND MORTALITY

Age	No. of Cases	Deaths	Mortality
1-10	1	1	100.00%
11-20	4	1	25.00%
21-30	23	5	21.70%
31-40	17	5	29.40%
41-50	3	1	33.33%
51-60	2	1	50.00%

Table 2 shows that there were seven females with three deaths, a mortality rate of 42.8 per cent. The males numbered forty-three with eleven deaths, a mortality rate of 25.5 per cent.

TABLE 2—SEX INCIDENCE AND MORTALITY

Sex	No. of Cases	Percentage of Cases	Deaths	Mortality
Females	7	14%	3	42.8%
Males	43	86%	11	25.5%

TIME FACTORS RELATED TO MORTALITY

The average fatal case arrived ninety-seven minutes after the injury occurred, and was operated upon an average of 135 minutes after admission to the hospital. The survivors, although arriving seventy-five minutes after injury, were not operated upon for an average of two hundred and ninety-seven minutes after admission. However, if two cases in which the delay amounted to eleven hours and seventy-six hours respectively are excluded, the average time from admission to operation is reduced to 115 minutes among the survivors. In both of these cases, delay was due to the lack of definite evidence of penetration. The average delay, amounting to about two hours, is largely utilized in the treatment of shock. Perhaps earlier laparotomy in the fatal cases may have salvaged some of this group.

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TABLE 3—TIME FACTORS RELATED TO MORTALITY

Type of Case	<i>Av. Time Injury to Admission</i>	<i>Av. Time Admission to Operation</i>
Survivors	75 minutes	297 minutes
Fatalities	97 minutes	135 minutes
Excluding two cases operated upon 11 hours and 76 hours respectively:		
Survivors	115 minutes	

CAUSES OF DEATH

In Table 4 it will be observed that hemorrhage and shock subsequent thereto accounted for 64.3 per cent of the deaths, while peritonitis, pulmonary embolism, pulmonary edema, massive atelectasis and asphyxia due to aspiration of vomitus accounted for the remaining 35.7 per cent. This means simply that in this series deaths from hemorrhage were twice as frequent as from all other causes combined.

TABLE 4—CAUSES OF DEATH

<i>Cause</i>	<i>No. of Cases</i>	<i>Mortality Rate</i>	<i>% of Deaths</i>
Hemorrhage and Shock	9	18	64.28%
Peritonitis	1	2	7.14%
Pulmonary Embolism	1	2	7.14%
Pulmonary Edema	1	2	7.14%
Due to Excess Salt Administration			
Massive Atelectasis	1	2	7.14%
Asphyxia Due to Aspiration of Vomitus	1	2	7.14%
Total	14	28	100.00%

RELATIONSHIP OF SHOCK AND HEMORRHAGE
TO MORTALITY

In Table 4 it is apparent that hemorrhage and shock accounted for 64.3 per cent of the deaths. Peritonitis, pulmonary embolism, atelectasis, pulmonary edema, and aspiration of vomitus during anesthesia accounted for only one death each. The mortality from hemorrhage alone is twice that of all these causes combined. Ten of twenty-two patients who arrived at the hospital in a state of profound shock died. It is apparent that three-fourths of those who died arrived in shock.

The mortality rate among the cases in shock was 45.4 per cent as compared with a mortality of only 16.6 per cent in the remaining patients.

TABLE 5—SHOCK ON ADMISSION

<i>State</i>	<i>No.</i>	<i>Lived</i>	<i>Died</i>	<i>% of Deaths</i>	<i>Mort. Rate</i>
In Shock	22	12	10	71.4%	45.4%
Not in Shock	28	24	4	28.6%	16.6%
Total	50	36	14	100.0%	28.0%

Hemorrhage as a factor is further emphasized by Table 6, in which the relationship of the amount of blood lost to the mortality rate is clearly suggested. Blood loss in the peritoneal cavity was measured in twenty-six cases. Six of these died. In the latter group, the average blood loss amounted to 1533 cc. The blood replacement in the group amounted to an average of 750 cc. of whole blood and an additional average of 50 cc. of plasma. On the other hand, the twenty survivors, in which the loss was measured, lost an average of 850 cc. of blood and received as replacement an average of 875 cc. of whole blood and 225 cc. of plasma. This quantity amounted to 129.4 per cent of the loss. Seven cases were picked from among the survivors to demonstrate that large blood loss does not necessarily cause death provided that the replacement is adequate, meaning cc. for cc. or more. In this group, the

TABLE 6—RELATIONSHIP OF BLOOD LOSS AND
REPLACEMENT TO MORTALITY

<i>Type of Case</i>	<i>Ave. Blood No. Loss</i>	<i>Average Replacement</i>	<i>Replacement Percentage</i>
Fatalities	6 1533	750 Blood 50 Plasma	52.10%
Survivors	20 850	875 Blood 225 Plasma	129.4%
Seven survivors with blood loss exceeding 1000 cc.	7 1471	1100 1214 Blood 714 Plasma	131.0%
		1928	

average blood loss amounted to 1471 cc. and the replacement consisted of an average of 1214 cc. of blood and 714 cc. of plasma. The percentage replacement amounted to 131 per cent of the loss.

MORTALITY AS A FUNCTION OF THE VISCUS INJURED

Only in cases where there is injury to single segments of the gastrointestinal tract can accurate comparisons of the mortality rates of injuries to the varied segments be made. This series is far too small to allow accurate appraisal in this regard. Table 7 shows that there is no significant difference in this series between the segments. This factor is in accord with the lower incidence of peritonitis as a cause of death. We expect to find fewer differences as more antibiotics and chemotherapeutic agents for combatting peritonitis appear. The liver poses a different problem, that of hemorrhage. There was a mortality of 20 per cent when the liver alone was injured. The present day use of gelfoam and oxycel will undoubtedly reduce this figure.

TABLE 7—MORTALITY AS A FUNCTION OF
SITE OF PERFORATION

Segments	Number of Cases	Deaths	Mortality Rate
Small Intestines	8	0	0
Liver	5	1	20%
Large Intestines	3	0	0
Stomach	2	0	0

MORTALITY AS RELATED TO THE NUMBER OF PERFORATIONS

The mortality as a rule increases with the number of perforations. In this series, no definite relationship was observed. This is brought out in Table 8. In some cases with less than five perforations, there were deaths; whereas, many survived with perforations exceeding this number. The number of perforations was accurately recorded in thirty-seven cases. Apparently the mortality is not too closely related to the number of perforations, but a large number of perforations

indicates a more severe injury with greater blood loss and the latter is more likely to produce death.

TABLE 8—MORTALITY AS A FUNCTION OF THE
NUMBER OF PERFORATIONS

Number of Perforations	Cases	Died	Mortality Rate
1	6	2	33.3%
2	6	1	16.6%
3	4	0	0%
4	7	3	42.85%
5	3	0	0%
6	1	1	100.00%
7	2	2	100.00%
8	4	2	50.00%
14	1	0	0%
21	1	1	100.00%
Designated simply "Multiple"	2	1	50.00%

DISTRIBUTION OF INJURIES AMONG ABDOMINAL ORGANS

Generally the larger the organ, the more frequently it is injured. Table 9 shows that the small intestines were injured in twenty-eight cases, the large intestines and liver in nineteen cases each, the stomach in fifteen cases, and the mesentery in thirteen. The omentum was damaged in six cases, the urinary bladder in four cases, the diaphragm in four cases and the kidney, pancreas and spleen in three cases each. The other organs were damaged no more than once in this series. Some of the factors which influence the frequency of injury to the abdominal organ are: 1) its relationship to the bony skeleton; 2) the position of the patient at the time of injury; 3) the size of the organ; 4) the position of the assailant.

EFFECTS OF ASSOCIATED INJURIES TO OTHER REGIONS

Rippy⁴ reported a mortality of 81.7 per cent for the combined abdominothoracic cases. Hamilton and Duncan¹ reported a mortality for 60.8 per cent and Hardt and Seed⁵ 56 per cent. There were only three cases in this series. Each, in addition to his abdominal injury, had unilateral or bilateral pneumothorax and hemothorax. One of these cases developed empyema but eventually sur-

TABLE 9.—DISTRIBUTION OF INJURIES TO ABDOMINAL VISCERA

Organ	Number of Cases
1. S. Intestines	28
2. L. Intestines	19
3. Liver	19
4. Stomach	15
5. Mesentery	13
6. Omentum/	6
7. Diaphragm	4
8. Urinary Bladder	4
9. Kidney	3
10. Spleen	3
11. Pancreas	3
12. Gall Bladder	1
13. Renal Vessels	1
14. Ext. Iliac Art.	1
15. Broad Lig.	1
16. Mesoappendix	1
17. Ileocolic Artery	1

vived so that there were no deaths in this group. This series is too small to allow for generalizations in regard to thoraco-abdominal injuries.

There were four cases with fractures of the spine with no deaths.

ANESTHESIA

All forms of anesthesia were employed. Table 10 summarizes the anesthetic data. There was only one anesthetic death. This patient was in fair shape at the time of induction, but aspirated vomitus before surgical anesthesia levels were reached. In many instances, the operative procedure was started under one form of anesthesia and completed under another. This happened most frequently when spinal anesthesia or regional block anesthesia were the initial agents. Spinal anesthesia was employed when the patient was in good condition; whereas regional block and open ether were employed in the poorer risk group. The majority of patients were operated upon under closed N₂O, O₂, ether anesthesia, this group numbering twenty-three. Although the mortality rates are given relative to the type of anesthesia, there was but one death directly related to anesthesia.

TABLE 10.—ANESTHESIA

Type	No. of Cases	No. of Deaths	Mortality
Open Drop	10	6	60%
Spinal	3	0	0%
Spinal N ₂ O, O ₂ Ether	2	1	50%
Spinal N ₂ O, O ₂	3	0	0%
N ₂ O, O ₂ Ether	23	4	17.39%
Pentathol, Ether (Open)	1	1	100.00%
Pentathol	1	0	0%
Spinal, Ether, Pentathol	2	0	0%
Spinal, Pentathol	1	0	0%
Pentathol, N ₂ O, O ₂	1	0	100.00%
Regional Block	1	0	0%
Pentathol	2	1	50%

COMBINATIONS OF VISCERA INJURED

In Table 9, the various combinations of viscera injured in the fatal cases are listed. Of the survivors, 48.5 per cent had multiple organs injured. Multiple injuries, on the other hand, occurred 92.8 per cent of the fatal cases. Unquestionably, the mortality is higher when multiple organs are damaged.

TABLE 11.—COMBINATIONS OF VISCERA INJURED IN FATAL CASES

Case No.	Organs Involved
1.	Stomach, duodenum, liver, renal vessels
2.	Jejunum, ileum, transverse colon
3.	Jejunum, ileum, transverse colon
4.	Jejunum, ileum, sigmoid, superior hemorrhoidal vein
5.	Stomach, liver, gall bladder, gastrohepatic omentum
6.	Liver, kidney, duodenum, ileum, ascending colon, transverse colon
7.	Jejunum, ileum, transverse colon, sigmoid, omentum
8.	Stomach spleen, (missed lesion)
9.	Stomach, jejunum, transverse colon, sigmoid, omentum
10.	Jejunum, stomach, mesentery, urinary bladder, liver
11.	Liver, cecum, (pulmonary embolism on 6th P. O. day)
12.	Jejunum, descending colon, mesentery
13.	Ileum, Ext. Iliac vein
14.	Liver

OPERATIVE PROCEDURE AND STATUS OF THE SURGEON

We are in accord with Rippy that the simplest procedure is the method of choice. The first consideration is the control of hemorrhage. This is done by ligature, suture, packing and by use of such material as gelfoam and oxycel. The latter agents are particularly useful in injuries of the liver. After bleeding is controlled, the entire gastro-intestinal tract is inspected in systematic fashion and each injured area carefully repaired. The latter is accomplished by simple closure in a transverse direction of each perforation. Occasionally, injury to a segment will be so severe that resection of the area is the method of choice. In this series resection of small bowel and re-anastomoses was carried out in six cases with one death, a mortality of 16.6 per cent (Table 12). In the case of large bowel injuries, the perforation may be closed safely at times by simple suture accompanied by proximal colostomy or cecostomy or by exteriorization of the loop. In Table 12 it can be seen that exteriorization was performed twice in this series, once along with nephrectomy and closure of a wound in the descending duodenum and once along with closure of multiple perforations of the small intestines in a two year old child. Both cases died. In one case a segment of small intestines was resected along with closure of a large bowel perforation and a proximal cecostomy with an uneventful recovery.

TABLE 12—OPERATIONS OTHER THAN SIMPLE SUTURE

Operation	No. of Cases	Mortality
Nephrectomy alone	1	00.00%
Nephrectomy with exteriorization of large bowel and simple repair of duodenum	1	100.00%
Exteriorization of loop of large bowel with closure of multiple small bowel perforations	1	100.00%
Resection of small intestines, closure of large bowel perforation and proximal cecostomy	1	00.00%
Resection of small intestines	6	16.6%

The spleen must be removed when damaged. One case in this series died because of hemorrhage from an injured spleen that was not removed. If the kidney is damaged beyond repair, it should be removed. If there is any hope for its repair more conservative treatment is desirable. In most instances of this kind a drain should be placed retroperitoneally down to the damaged kidney. The kidney was removed twice in this series, once alone with recovery and once along with other procedures. This case, mentioned in the preceding paragraph, died. A damaged gall bladder should be removed unless the injury lies near the fundus and the patient's condition is grave. Under these circumstances cholecystostomy by insertion of a tube through the debrided opening into the organ is satisfactory.

DISCUSSION

This study indicates that the first and probably most important item in the treatment of severe perforating gunshot wounds of the abdomen is rapid and adequate replacement of blood loss. Neglect in this phase of treatment will result frequently either in death prior to abdominal exploration or increase in the hazards of operation. Control of shock when possible results in a smoother operative procedure which makes haste of operating relatively unimportant. The surgeon can more diligently search for perforations. Anti-shock measures should be instituted on all patients as soon as possible. If it becomes evident that treatment will not result in abatement of shock and that hemorrhage is continuing, it is necessary to operate earlier in order to control hemorrhage. In most instances, however, hemorrhage stops or slows spontaneously so that time may be wisely taken to restore the blood volume. We have lost a few patients due to injury of major vessels. The use of present day devices for rapid transfusion⁸ may have salvaged some of these.

Once shock is controlled, abdominal exploration should be undertaken without delay. The operative procedure should be carried out as rapidly as possible but not at the neglect of thoroughness. One perforation that is overlooked may result in death just as readily as many.

Every patient in this series received penicillin, sulfa or streptomycin. Some have received all of these. There can be little doubt that the incidences

of peritonitis and lung complications have been lessened by these agents. With the coming of more of these agents a further decline is expected.

Every patient in this series received gas gangrene antiserum and tetanus antitoxin. There were no cases of tetanus or gas gangrene in this series.

The treatment of these cases has been carried out largely by the resident staff. The value of their service in achieving a low mortality equals the value of the previously mentioned factors.

During the past two years the mortality has shown further decline as indicated by the mortality rate of 13.6 per cent in the last 22 cases.

SUMMARY

A series of fifty consecutive cases of perforating gunshot wounds of the abdomen have been subjected to statistical study and presented. These cases have been considered from many points of view in an effort to enumerate the factors responsible for achieving a low mortality. We have discussed our belief that present day decline in the mortality rate is due to the following three factors: 1) adequate replacement of blood loss, 2)

the availability and use of the sulfa drugs and the various antibiotic agents, and 3) the presence of a competent resident staff. As improvements occur in these three areas, further decline in mortality is anticipated.

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